Flowers and insects. XVI.[1]

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NOTHOSCORDUM STRIATUM Kunth. *N. ornithogaloides* (Walt.) Kunth.—The plant is common in woods, blooming from April 10th to May 16th. The scapes grow 1 or 2^{dm} high and bear small umbels of white flowers. The flowers are about 10^{mm} long and expand 10 or 12^{mm}. The sepals are approximated below, the base of the tube being greenish and narrowed by the ovary and the filaments of the six stamens. The flowers are homogamous, the stigma occupying the center of the circle of anthers and somewhat surpassing them. Spontaneous self-pollination can hardly occur.

The flower is remarkable for being abundantly visited by numerous species of bees of the genus *Nomada*. On seven days, between April 20th and May 9th, I captured the following visitors:

HYMENOPTERA—*Apidæ:* (1) Nomada luteoloides Rob. ♂; (2) N. superba Cr. ♂, freq.; (3) N. americana Kby. ♂; (4) N. maculata Cr. ♂♀, ab.; (5) N. cressonii Rob. ♂♀, ab.; (6) N. sayi Rob. ♂♀, freq.; *Andrenidæ:* (7) Augochlora similis Rob. ♀, ab.; (8) Halictus confusus Sm. ♀, s. and c. p.; (9) Andrena sp. ♀, s. and c. p., freq.

DIPTERA—*Syrphidæ:* (10) Mesograpta marginata Say; (11) Sphaerophoria cylindrica Say, ab.

LEPIDOPTERA—*Rhopalocera:* (12) Colias philodice Gdt.; (13) Pieris rapæ L.; (14) Lycaena comyntas Gdt.; *Heterocera:* (15) Plusia simplex Gn.—All only sucking, except (8) and (9).

CAMASSIA FRASERI (A. Gray) Torr.—The flower is described and figured by Loew (2) from material growing in the Berlin Garden. According to his account, the inflorescence consists of a long loose raceme of twenty or more flowers. The flowers are directed obliquely upwards and have widely expanded sepals. The anther faces are directed forwards so as to touch the visitors, and the stigma is about 4^{mm} in advance of them. Nectar is secreted by septal glands and collects under the base of the ovary.

Loew (1) saw the flowers visited by *Apis mellifica* and *Osmia rufiventris*. He, however, does not consider them to be adapted to these middle-sized bees, but to Lepidoptera, which

[1]Contributions to an account of the ecological relations of the entomophilous flora and the anthophilous insect fauna of the neighborhood of Carlinville, Illinois.

he supposes may hover in front of the flower in such a way as to come in contact with the anthers and stigma.

The flowers described by him are certainly larger than any I have seen. When watching the flowers being visited by bees and Syrphidæ, it did not occur to me that there was any difficulty in their effecting pollination, though the smallest might obtain the nectar without often touching anthers or stigma. I see nothing about the flower to indicate an adaptation to insects with long tongues or to those of large size.

About Carlinville, the plants are common, sometimes being collected in quite conspicuous patches, which are very attractive to insects. The blooming time is from April 25th to May 16th. The scapes rise from 3 to 6^{dm} high. The flowers are pale blue, or sometimes white. The sepals expand widely, to the extent of two or more cm. The stigma is receptive with, or a little in advance of, the dehiscence of the anthers. The stamens, however, are so strongly divergent that insects may easily touch the stigma before coming in contact with them. The flowers are evidently adapted to bees, but are visited by flies and other insects. On the morning of May 8th, in about an hour, I captured the following visitors:

HYMENOPTERA—*Apidæ:* (1) Apis mellifica L. ☿, s., ab.; (2) Bombus americanorum F. ♀, s., one; (3) Synhalonia frater Cr. ♂♀, s., freq.; (4) S. belfragei Cr. ♂, s.; (5) Ceratina tejonensis Cr. ♂, s.; (6) C. dupla Say ♂, s.; (7) Osmia albiventris Cr. ♂♀, s. & c. p.; (8) Nomada superba Cr. ♂♀, s., freq.; (9) N. americana Kby. ♂, s.; *Andrenidæ:* (10) Halictus pectoralis Sm. ♀, s., freq.; (11) H. forbesii Rob. ♀, s.; (12) H. lerouxii Lep. ♀, s. & c. p.; (13) H. ligatus Say ♀, s. & c. p.; (14) H. fasciatus Nyl. ♀, s. & c. p., ab.; (15) H. pilosus Sm. ♀, s. & c. p., ab.; (16) H. confusus Sm. ♀, s. & c. p., freq.; (17) H. pruinosus Rob. ♀, s. & c. p., freq.; (18) Augochlora pura Say ♀, s.; (19) A. similis Rob. ♀, s.; (20) Agapostemon viridula F. ♀, s.; *Vespidæ:* (21) Polistes pallipes Lep., s.; *Eumenidæ:* (22) Odynerus tigris Sauss., s.

DIPTERA—*Syrphidæ:* (23) Chrysogaster pictipennis Lw.; (24) C. nitida Wd.; (25) Eristalis dimidiatus Wd.; (26) Syritta pipiens L.; *Tachinidæ:* (27) Micropalpus fulgens Mg.; *Sarcophagidæ:* (28) Cynomyia mortuorum L.; (29) Helicobia helicis Twns.; *Muscidæ:* (30) Lucilia cornicina F.; (31) L. caesar L.; *Anthomyidæ:* (32) Phorbia acra Wlk.; (33) P. fusciceps Zett.—all s.

LEPIDOPTERA—*Rhopalocera:* (34) Pyrameis atalanta L.; (35) P. huntera F.; (36) Colias philodice Gdt., freq.—all s.

COLEOPTERA—*Coccinellidæ:* (37) Hippodamea 15-maculata Muls., s.

On the literature of *Camassia* see:

(1) Loew, Beobachtungen über Blumenbesuch von Insekten an Freilandpflanzen des Botanischen Gartens zu Berlin. Jahrb. Bot. Gartens Berlin **3**: 82, 117. (14, 49) 1884.—(2) Loew, Blüthenbiologische Beiträge, II. Pringsheim's Jahrbücher **23**: 76–77. 1892.

POLYGONATUM Adans.—This genus contains perennial herbs with pendulous, tubular bell-shaped, greenish flowers, which are homogamous, adapted to bumble-bees, or other long-tongued bees, though sometimes also visited by Lepidoptera and small insects which crawl into the tube. Self-pollination, as well as cross-pollination, may be effected by insects, or in some cases spontaneous self-pollination may occur by the anthers coming in contact with the stigma. That nectar is secreted by the ovary was known to Sprengel (1), while Bonnier (2) and Grassmann (7) have indicated the presence of septal glands.

We may suppose that the pendulous position of the flowers owes its origin to the fact that it renders them less convenient to other insects, but equally convenient to the higher bees, which are the most efficient pollinators; and that the resulting protection to pollen and nectar is merely an incidental effect.

On the theory that the flowers are adapted to bumble-bees, it is hard to understand the observation of Schulz (14) that the flowers of *P. verticillatum*, *multiflorum* and *officinale* are frequently perforated by them. In the case of the short-tongued species, like *B. terrestris*, we may suppose that the perforation is made because the bee cannot reach the nectar in the legitimate way. In the case of *P. verticillatum* the larger buds were also perforated. If the three species have nectar secreted prematurely in the bud, we might explain the behavior of the long-tongues by supposing that they have discovered this and cut through the tube without taking the trouble to find out whether the mouth is open or not.

POLYGONATUM GIGANTEUM Diet. *P. biflorum commutatum* (R. & S.) Morong.—The tube measures about 17^{mm} long and expands about 5^{mm} at the throat. The latter is obstructed by the filaments, which are inserted on the middle of the tube and are inclined inwards. The style is so short that, owing to the position of the flower, spontaneous self-pollination is impossible, though insects may with their proboscides carry pollen back to the stigma of the same flower. The flowers bloom from the 17th of May to the 14th of June. On May 23rd, 27th and June 1st I saw them visited by:

Apidæ: (1) Bombus vagans Sm. ♀, s. & c. p.; (2) Anthophora ursina Cr. ♀, s. & c. p.; (3) A. abrupta Say ♀, s. & c. p.

On the literature of *Polygonatum* see:

(1) Sprengel, Das entdeckte Geheimniss 198–9. 1793. *Convallaria polygonatum*, *multiflora*.—(2) Bonnier, Les Nectaires 23, 36, 86, 136,

192. 1879. *P. vulgare, multiflorum.*—(3) Müller, Alpenblumen 52–4. 1881. *C. polygonatum, verticillata.*—(4) Müller, Die Entwickelung der Blumenthätigkeit der Insekten. Kosmos **9**: 208. 1882. *C. polygonatum.*—(5) Durand, Sur quelques particularités d' organisation de la fleur des Polygonatum. Bull. mens. Soc. Linn. Paris **1882**: 322–3. (Just **10**²: 75).—(6) Loew, Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin **3**: 99 (31) 1884. *P. officinale.*—(7) Grassmann, Die Septaldrüsen. Flora **67**: 118, 135. 1884. *P. officinale, multiflorum, verticillatum.*—(8) Engler, Liliaceæ. Engler u. Prantl, Die natürlichen Pflanzenfamilien 2: 15–16. 1887. (Just **16**¹: 555).—(9) Jordan, Beiträge zur physiol. Organographie der Blumen. Ber. der Deut. Bot. Ges. **5**: 330. 1887. *P. latifolium.* (Loew, Floristik 350).—(10) Pammel, On the pollination of Phlomis tuberosa and the perforation of flowers. Trans. St. Louis Acad. Sci. **5**: 254, 273. 1888. *C. polygonatum.*—(11) Kirchner, Flora von Stuttgart und Umgebung 70. 1888. *P. verticillatum.*—(12) Almquist, Om honings gropens s. k. fjäll hos Ranunculus och om honing salstringen hos Convallaria polygonatum och multiflora. Bot. Notiser **1889**: 66. (Just **16**¹: 533).—(13) Almquist, Ueber Honigerzeugung bei Convallaria polygonatum und multiflora. Bot. Centralb. **38**: 663. 1889. (Just **17**¹: 505).—(14) Schulz, Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen 2: 166, 224. Bibliotheca Botanica 17: —. 1890. (Just **18**¹: 524).—(15) MacLeod, Over de bevruchting der bloemen in het Kempisch gedeelte van Vlaanderen. Bot. Jaarboek **5**: 311–13. 1893. *P. multiflorum.*—(16) Loew, Blütenbiologische Floristik. 166, 350. 1894. *P. multiflorum, verticillatum, latifolium, officinale.*

SMILACINA STELLATA Desf. *Vagnera stellata* (L.) Morong.—This plant occurs on rich banks, sometimes forming rather large patches. It grows 4 or 5^{dm} high and bears a small terminal raceme of white flowers. The stem is bent to one side so that the axis of the raceme is directed horizontally. The flowers are arranged on the upper side so that the sepals are expanded horizontally, or nearly so. The flowers are therefore in the most favorable position for the visits of the less specialized insects, and the nectar and pollen are easily reached, the pollen in fact being completely exposed. The flowers are proterogynous, newly opened ones having receptive stigmas and closed anthers.

The indications point to an adaptation to the less specialized bees—*Andrenidæ*—which predominate during the blooming time and are the principal guests. The blooming time is from April 25th to May 12th. The following list was observed on April 30th:

BEES—*Apidæ:* (1) Ceratina tejonensis Cr. ♂, s.; (2) Nomada cressonii Rob. ♂, s.; *Andrenidæ:* (3) Andrena vicina Sm. ♀, s.; (4) A. cressonii Rob. ♀, s. & c. p.; (5) Halictus 4-maculatus Rob. ♀, s. & c. p.

freq.; (6) H. lerouxii Lep. ♀, s. & c. p.; (7) H. obscurus Rob. ♀, s. & c. p.; (8) H. stultus Cr. ♀, s. & c. p.; (9) H. sp. ♀, s. & c. p.; (10) Augochlora viridula Sm. ♀, s.; (11) A. labrosa Say ♀, s. & c. p.; (12) H. pura Say ♀, s. & c. p., freq.; (13) A. similis Rob. ♀, s. & c. p.; (14) Sphecodes smilacinæ Rob. ♀. s.

FLIES—*Empidæ:* (15) Empis humilis Coq. (MS.) s., freq.; *Bombylidæ:* (16) Bombylius major L., s.

SMILACINA RACEMOSA Desf. *Vagnera racemosa* (L.) Morong.—The stem is simple and inclined to one side so as to throw the terminal panicle into an horizontal position. The flower consists of six divergent stamens and the pistil. The segments of the perianth are very small and never enclose the stamens, the anthers being evident from the early bud. With the exception of the anthers all of the parts of the flower are white. By an increase in the number of flowers the panicle of this species is rendered even more conspicuous than the raceme of the preceding. The plant is more common, but is not often found in patches like *S. stellata.* The flowers are proterogynous with long lived stigmas. Cross-pollination is further facilitated by the stamens being strongly divergent. Spontaneous self-pollination can hardly occur.

There seems to be no nectar,[2] and the few visitors noted only sought for pollen. The blooming season is from May 7th to 30th. On the 17th, 18th and 23rd the following visitors were observed:

Andrenidæ (1) Halictus pectoralis Sm. ♀, c. p.; (2) H. 4-maculatus Rob. ♀, c. p.; (3) H. stultus Cr. ♀, c. p.

Scarabaeidæ: (4) Trichius affinis Gory, f. p.

UVULARIA L.—Nectar is secreted by the sepals (Engler 2). In the case of *U. perfoliata*, Alice Carter (4) notes the abundant visits of bumble bees. At Madison, Wisconsin, Trelease (MS. notes) saw it visited by *Osmia albiventris* ♂. He regards the flower as probably spontaneously self-pollinating. On account of the shorter stamens, this may not be so likely as in the following.

UVULARIA GRANDIFLORA Smith.—Kerner (3) mentions this species as an example of simple autogamy.

The stems grow 2 or 3^{dm} high and bear one or two greenish yellow, pendulous flowers. The divisions of the perianth are closely approximated and twisted, which makes it difficult for all except the largest and strongest bees to enter. Nectar is secreted and lodged in a pit at the base of each segment.

[2] This species has septal glands, according to Grassmann, Die Septaldrüsen. Flora 67: 118. 1884.

Access to it is impeded by the segment lying close to the opposite filament. The long anthers surpass the style. The outer three begin to discharge their pollen before the others, and the dehiscence begins at the base of the anther and proceeds upwards. The flowers are homogamous. The three divisions of the style are widely divergent, so that the stigmas are protruded between the anthers. They thus come in the way of a bee crawling in between the anthers and sepals. A bee laden with pollen will invariably effect cross-pollination, if it visit the flower early, and it may accomplish the same result later. But after the line of dehiscence has reached the stigmas, there is a chance of spontaneous self-pollination. Cross-pollination commonly results in cross-fertilization between distinct plants.

The observations of Trelease, at Madison, give results essentially agreeing with the above account. He saw the flowers visited by bumble bees.

In my neighborhood, the blooming season is from April 12th to May 6th. April 20th, 23d, 25th, 26th and 29th, the following bees were observed on the flowers:

Apidæ: (1) Bombus separatus Cr. ♀, s.; (2) B. ridingsii Cr. ♀, s.; (3) B. americanorum F. ♀, s.; *Andrenidæ:* (4) Andrena vicina Sm. ♀, s. & c. p.; (5) A. pruni Rob. ♂, s.

The flowers are evidently adapted to Bombus females, the only sex flying during the blooming season. The pollen collecting visit of *Halictus cylindricus* ♀ in the Berlin Garden (1) has no significance.

On the literature of *Uvularia* see:

(1) Loew, Beobachtungen über Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. bot. Gartens Berlin. **3**: 278 (76). 1884. *U. grandiflora* (flava)—(2) Engler, Liliaceæ. Engler u. Prantl, Die nat. Pflanzenfamilien. 2: 15. 1887.—(3) Kerner, Pflanzenleben **2**: 173, 330. 1891.—(4) Carter, Notes on pollination. Bot. Gaz. **17**: 21. Ja. 1892. (Just **20**[1]: 475).

TRILLIUM L.—From observations made in the Berlin Garden Loew (2) records that in *T. grandiflorum* Salisb. the flowers are proterandrous. They are white and expand about 9.5[cm]. The stamens are longer than the pistil by about 5[mm]. Loew was doubtful about the occurrence of nectar, but in the Botanical Garden at South Hadley, Mass., Miss Carter (3) noted its presence and says that it is secreted by septal glands. At first the mouth of the flower is closed by the anthers. Later the petals expand further, the stamens sep-

arate above, and the stigmas appear between them. She saw hive bees collecting the pollen. In view of Loew's observations and the statement of the Manual that the stamens exceed the stigmas, it is not easy to understand how the recurving stigmas will meet the anthers.

The white nodding flowers of *T. cernuum* L., according to Miss Carter, are slightly proterandrous, with a chance of spontaneous self-pollination by the stigmas recurving to meet the shorter stamens. She saw a bumble bee visiting the flowers for nectar.

T. erectum L., according to Loew, is a dark purple pollen-flower with offensive odor. The flower with its expanded or recurved petals measures about 7.5^{cm} across. In cases observed by him the anthers did not reach the height of the stigmas, but he mentions that the latter bend backwards. Miss Carter found the stigmas and anthers at nearly the same level. She regards spontaneous self-pollination as the rule. The Manual says that the stamens equal or exceed the stigmas. According to Weed (4) this species is proterandrous and adapted to cross-pollination. In New Hampshire he saw the flowers visited for pollen by two or three species of flesh-flies, among them *Lucilia cornicina* F. Miss Carter saw the flowers visited by four beetles, "certainly of little avail in cross-pollination and probably too late." The absence of nectar makes strong dichogamy improbable. The odor, color and the observed visits of flesh-flies suggest an adaptation to these insects, but the absence of nectar is hard to understand. The pinkish and white forms may be more attractive to insects, if they want the disagreeable odor and secrete nectar, but the greenish form is probably the most degraded. In fact this range of variation itself may be a sign of degradation. The flower seems to be losing its hold on insects and to form a transition between the other entomophilous species of *Trillium* and the still more degraded *T. sessile* and *recurvatum*.

TRILLIUM SESSILE L.—Loew (1, 2) classes this flower with *T. erectum*, but I have noted no disagreeable odor about it. We saw a beetle, *Cetonia aurata* L., gnawing the anthers. Miss Carter says that self-pollination seems inevitable.

In Patterson's Catalogue of Illinois Plants it is credited to Kankakee and Wabash counties. I have found it in only one locality. The sepals are not reflexed as in the next. The petals are greenish except at base, where they are dark pur-

ple, like the stamens and stigmas. This color is the only entomophilous character the plant shows. The stigmas are very large and have their edges thrown into convolutions. This great development seems to insure contact with the large anthers which surround them. On one occasion I found a number of beetles, *Centrinites strigicollis* Casey (Curculionidæ), among the anthers, feeding upon the pollen, and pairing. They seemed more likely to secure self-pollination, though in their slow movements to other plants cross-pollination might be effected. The flowers bloom from April 24th to May 15th.

TRILLIUM RECURVATUM Beck.—This is a common plant, blooming from April 8th to May 16th. The stems grow a few dm. high and bear single flowers, which are sessile upon the circle of three leaves. The sepals are green and reflexed. The petals are erect, arch over the stamens and are narrowed at base and tip. They are dark purple. The filaments and stigmas are of the same color, but the anthers are nearly black. The anthers are long and rigid, having a very broad connective which is produced above into a blunt point. They form a rather rigid cone over the pistil, so that the pollen can hardly be eaten or collected by insects. I find no nectar nor odor, in fact nothing to induce insect visits, except the purple color. It is possible that small flies resort to these flowers at night. The stigmas become elongated and recurved, so that with their convoluted edges they are quite likely to receive pollen from the anthers.

On the pollination of *Trillium* see:

(1) Loew, Weitere Beobachtungen über Blumenbesuch von Insekten an Freilandpflanzen. Jahrb. Bot. Gartens Berlin **4**: 149. 1886.—(2) Loew, Blüthenbiologische Beiträge. II. Pringsheim's Jahrbücher **23**: 78–9. 1892. (Just **19**[1]: 417)—(3) Carter, Notes on pollination. Bot. Gaz. **17**: 20–1. 1892. (Just **20**[1]: 475)—(4) Weed, Ten New England blossoms and their insect visitors 53–60. 1895.

MELANTHIUM VIRGINICUM L.—This plant is rare. It grows on prairies, sometimes in large patches. The stem rises from 1 to $1\frac{1}{2}^{m}$ high and is terminated by a large pyramidal panicle of white flowers. The old flowers, which turn greenish yellow, are persistent, so that they render the inflorescence more conspicuous.

The flowers are andro-monoecious, most of them being perfect, but the uppermost ones in the panicle are staminate. They expand horizontally from 15 to 30^{mm}. The sepals are

nearly heart-shaped with long claws. At the base of the blade of each sepal there is a shallow depression containing two yellow nectar glands. The nectar is thus completely exposed. The claw of each sepal bears a stamen with an extrorse anther held in such a position as to touch a large insect which sips the nectar. The three outer anthers dehisce first. The perfect flowers are proterandrous, the stigmas not becoming receptive until the anthers have fallen. The three styles are strongly divergent, so that the stigmas may touch the insects visiting the sepals for nectar.

The flowers show a very peculiar assemblage of visitors, mostly flies and beetles. The latter seem to be the ones for which the adaptations are intended. Of these *Trichius piger* is the most abundant visitor that I have observed, and it can readily affect pollination. The flowers are of rather large size, and, owing to their completely exposed nectar, admit insects which can obtain nectar but can hardly touch anthers or stigmas.

Melanthium Virginicum blooms from the 16th of June to the 11th of July. The list of visitors was observed on July 3d and 5th.

DIPTERA—*Syrphidæ:* (1) Mesograpta marginata Say; (2) Syritta pipiens L.; *Tachinidæ:* (3) Trichopoda pennipes F.; (4) Cistogaster occidua Wlk.; (5) C. immaculata Mcq.; (6) Jurinia smaragdina Mcq.; (7) Micropalpus fulgens Mg.; (8) Phorocera edwardsii Will.; (9) Atrophopoda singularis Twns.; *Sarcophagidæ:* (10) Sarcophaga cimbicis Twns.; *Muscidæ:* (11) Lucilia sp.; (12) L. cornicina F.; (13) Musca domestica L.; *Anthomyidæ:* (14) Anthomyia sp.; (15) A. albicincta Fll.—all s.

COLEOPTERA—*Lampyridæ:* (16) Photinus pyralis L.; *Scarabaeidæ:* (17) Trichius piger F. freq.; *Chrysomelidæ:* (18) Diabrotica atripennis Say; *Mordellidæ:* (19) Mordella melaena Germ.; (20) M. marginata Melsh.; *Curculionidæ:* (21) Centrinites strigicollis Casey—all s.

HYMENOPTERA—*Andrenidæ:* (22) Halictus confusus Sm. ♀; *Sphecidæ:* (23) Sphex ichneumonea L.; *Chalcididæ:* (24) Perilampus triangularis Say—all s.

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